31.0 SACRAMENTO RIVER WINTER-RUN CHINOOK ESU

31.1 BACKGROUND

31.1.1 Description of the ESU

The Sacramento River Winter-run Chinook Evolutionarily Significant Unit (ESU) consists of a natural, composite natural population, and all winter-run Chinook salmon are Endangered Species Act- listed as part of the population and the ESU. Critical habitat for winter-run Chinook salmon was designated on June 16, 1993, and includes the Sacramento River from Keswick Dam (river mile [RM] 302) downstream to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of the San Francisco Bay (north of the San Francisco Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.

31.1.2 Status of the ESU

Sacramento River winter-run Chinook salmon originally were listed as threatened in November 1990, and reclassified as endangered in January 1994 (59 FR 440), due to the continuing decline and increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and continuing threats to the population. The population had dropped nearly 99 percent between 1966 and 1991, and despite conservation measures to improve habitat conditions, the population continued to decline. A draft recovery plan was published in August 1997 (NOAA Fisheries 1997). Winter-run Chinook salmon historically spawned in the headwaters of the McCloud, Pit, and Little Sacramento rivers and Hat and Battle creeks. Construction of Shasta Dam in 1943 and Keswick Dam in 1950 blocked access to all of these waters except Battle Creek, which is blocked by a weir at the Coleman National Fish Hatchery and other small hydroelectric facilities (NOAA Fisheries 1997). Most of the current winter-run Chinook salmon spawning and rearing habitat exists between Keswick Dam and Red Bluff Diversion Dam in the Sacramento River. In the assessment of the ESU, 59 percent of the West Coast Salmon Biological Review Team (BRT) voted for the category “in danger of extinction”, 38 percent voted for the “likely to become endangered” category, and the remaining 3 percent voted for the “neither” category (BRT, 2003). The BRT expressed serious concerns regarding the effects of artificial propagation on ESU productivity, spatial structure, and diversity; but believed that hatchery effects on ESU abundance was positive.

31.2 ASSESSMENT OF HATCHERY PROGRAMS

There is only one population in the ESU. Winter-run Chinook salmon are removed from the naturally spawning population from the Keswick Dam fish trap and occasionally at the Red Bluff Diversion Dam fish trap, and propagated for the winter-run conservation program at Livingston Stone National Fish Hatchery (LSNFH). Other winter-run are trapped from the natural population or provided by LSNFH for two winter-run Chinook salmon captive broodstocks. The following section presents a summary of the broodstock/program history, similarity between

hatchery origin and natural origin fish, program design, and program performance of these artificial propagation programs (Table 31.1).

Table 31.1. Artificial Propagation Programs which release winter-run Chinook salmon within the geographical area of the SRWC ESU.

Program	Type	Included in ESU	Description	Production Level	Year Initiated
Livingston Stone National Fish Hatchery	integrated	yes	smolt	250,000	1989
Captive Broodstock Program	integrated	yes	captive rearing	variable	1991

31.2.1 Sacramento River Population/Winter-run Chinook Salmon Conservation Program

When a winter-run Chinook salmon conservation program began in 1989, the population estimate for the winter-run Chinook salmon ESU was estimated to be at 647 fish. The population was further reduced to 192 individuals in 1991, and 184 fish in 1994. A winter-run recovery plan was drafted (NOAA Fisheries 1997), with recommendations for fishing protection measures, a temperature control device at Shasta Dam, and hatchery supplementation. The implementation of these conservation measures began to reduce the risk of winter-run extinction, reflected in the 2003 winter-run population estimate of 9,757 fish (CDFG 2004). The delisting criteria developed for the winter-run Chinook salmon ESU recovery includes (1) a mean annual spawning abundance of 10,000 females over any 13 consecutive years; (2) a geometric mean of the cohort replacement rate (CRR) greater than 1.0 over those same 13 years. Estimates of criteria are based on natural production and not include hatchery-produced fish; and (3) there must be a system in place for estimating spawning run abundance with a standard error less than 25% of the estimate, on which to base the calculation of the population criteria. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the CRR is estimated must be increased by one additional year for each 10% of additional error above 25%.

31.2.1.1 Program History. The winter-run Chinook salmon conservation program was operated at Coleman NFH from 1989-1994, but was relocated at a newly constructed Livingston Stone NFH on the mainstem Sacramento River in 1997. The captive broodstock program held at UC-Davis Bodega Marine Laboratory (BML) was able to propagate winter-run Chinook salmon for the 1995-1996 year classes in the interim. The goal of the conservation program is to increase the number of winter-run spawners in the natural environment, thereby contributing to ESU recovery.

Winter-run Chinook salmon captive broodstocks are held at both Livingston Stone NFH and the BML to assure a source of gametes for the winter-run propagation program if natural returns are too low to provide adequate numbers of adults as broodstock (USFWS 2001). Captive fish also play a role in winter-run Chinook salmon research studies and also preserve genetic material as

an “insurance policy” against extinction of the winter-run Chinook salmon population.

31.2.1.2 Broodstock History. The winter-run Chinook salmon artificial propagation program has a broodstock collection target of 15% of estimated upriver winter-run escapement, up to a maximum of 120 natural-origin winter-run Chinook salmon broodstock per brood year (USFWS 2001). The percent of natural females collected for the captive broodstock program is a function of the estimated number of natural-origin females available. The program is designed to capture a maximum of about 60 females when the population is estimated to be 800 or more (i.e., 400 natural-origin females). No fewer than 20 adults will be taken for the broodstock regardless of run size. Hatchery-origin winter-run Chinook salmon incorporated as broodstock do not exceed 10% of the total number of winter-run Chinook salmon spawned.

31.2.1.3 Similarity of Hatchery Origin to Natural Origin Fish. Fish chosen for artificial propagation from the natural population are first genetically confirmed as winter-run Chinook salmon before they are spawned. Winter-run Chinook salmon are well differentiated genetically from other Chinook salmon runs in the ESU, as confirmed by allozyme, mitochrondrial DNA, microsatellite DNA, and a major histocompatibility (MHC) complex gene analyses of Central Valley Chinook salmon tissues. Winter-run genetic markers were identified through research carried out at BML, and applied to the genetic management to the winter-run conservation program (BML/USFWS, 2001). The program follows a spawning matrix designed to maximize genetic diversity and maintain genetic family lines from the wild population.

31.2.1.4 Program Design. The winter-run conservation program is managed by the U.S. Fish and Wildlife Service (USFWS), and guided by a network of subcommittees of the Interagency Ecological Program (IAP) Central Valley Salmonid Project Work Team. There is no directed commercial or recreational fishing on winter-run Chinook salmon, and recreational and commercial fishery conservation measures are in place to help minimize impacts to winter-run. The annual production goal is 250,000 pre-smolt winter-run Chinook salmon sub-yearlings (average 90mm fork length) at 60/lb., for January release at dusk at Sacramento River Mile 299. To reduce the risk of losing a large proportion of winter-run Chinook salmon by accident or predation, fish are released in two separate groups.

The captive broodstocks are in the process of being phased out as the natural winter-run population recovers. The LSNFH will continue to maintain a captive population until the 2006 completion of a comparative migration study involving wild x wild winter-run fish crosses with wild x hatchery winter-run fish crosses.

31.2.1.5 Program Performance. Hatchery winter-run Chinook salmon are 100 percent adipose fin-clipped and given a coded wire tag. Any marked winter-run juvenile that is captured before completion of out-migration may be sacrificed for its “tag” information. All winter-run fish broodstock are tagged with “passive integrated transponder”(PIT) tags to keep tract of family groups. Redd surveys are carried out annually by helicopter to enumerate the spawning population, and carcass surveys follow up to determine reproductive success. Spawned-out hatchery winter-run are confirmed in the surveys each year. Juvenile winter-run may be trapped at the Red Bluff Diversion Dam rotary screw traps in their outmigration to provide an estimate of

production. All in-river winter-run Chinook salmon spawn above the dam, and spatial structure is determined by temperature modulation from Shasta Dam.

31.2.1.6 VSP Effects

Abundance - Winter-run Chinook salmon abundance has increased since the initiation of the current winter-run Chinook salmon conservation program. The weakest cohort (BY 1991) has increased seven times (7X) in magnitude; the next two cohorts (BY 1992 and 1993) have increased six times (6X) and twenty-one times in magnitude (21X), respectively (CDFG 2003).

Productivity - Hatchery winter-run Chinook salmon are 100 percent adipose-clipped and tagged, making it possible to assess natural-origin fish abundances. The majority (90+ percent) of artificially propagated winter-run Chinook salmon are progeny of wild broodstock and are released as sub-yearlings. This low level of intervention into the natural life cycle for sub-yearling release groups decreases their risk of domestication, i.e., reduction of fitness to the natural environment. The fecundity of winter-run captive broodstock is measurably reduced from the wild population (3000 - 3800 eggs/wild female vs.1800 eggs/captive female); however, captive fish have only incidently supplemented the artificial propagation program, most significantly in 1996 and 1997 when the artificial propagation program exclusively utilized BML captive broodstock for artificial propagation. A breeding protocol has been designed for the winter-run artificial propagation program to equalize the contributions from captured winter-run spawners, and to insure minimal risk that the program would not reduce the effective population size or the mean fitness of the wild winter-run Chinook population..

Spatial Structure - Winter-run occupy a habitat maintained and protected by a network of agencies and the Endangered Species Act. The spatial structure of the population has actually decreased by 50 percent because the temperature control device is no longer works efficiency, the Central Valley Project has lost water supplementation from the Klamath Basin, and water operations will increase pumping rates because of the “dry year regime.” It is recognized that a crucial step in the recovery of the winter-run ESU is the establishment of a second winter-run population within a self-sustaining, viable habitat.

Diversity - Winter-run genetic diversity had been lost when remnant winter-run populations below Shasta Dam merged into the single population that now comprises the ESU. The conservation program has preserved the existing winter-run Chinook salmon genome during the time when the natural population was most vulnerable to extinction, and it continues to maintain family lines in the spawning matrix of the artificial propagation and captive rearing programs. Through a “rapid response” protocol, all fish utilized as broodstock are first genetically confirmed as winter-run. Nearly all of the coded-wire tags recovered during the 2001 carcass survey were from both the 1998 and 1999 brood year releases. Each tag code recovered represented an individual family group or cluster of groups, indicating that the hatchery population maintained the genetic diversity of their parent stock in 2001.

31.3 CONCLUSION

Existing Status: Endangered
BRT Finding: Endangered
Recommendation: Endangered

31.3.1. ESU Overview

31.3.1.1 History of Populations. There is only a single population present in this ESU, representing the genetic merging of several populations that at one time inhabited the upper Little Sacramento, McCloud, and lower Pitt Rivers blocked by Shasta Dam in 1943. Historical abundance was estimated to be approximately 200,000 Chinook salmon before the loss of 100 percent of winter-run spawning habitat. Additional declines resulted from unscreened water diversions, harvest impacts, predation, adverse temperatures and flow conditions, urban and agricultural development, and major levee channelization, reducing the population to 184 individuals in 1994. The remaining number of winter Chinook salmon was sustained by cold-water releases from Shasta Dam, which created suitable conditions to 100 km downstream. Winter-run remain vulnerable under management of their artificial habitat when in conflict with other water users or drought cycles. Winter-run also face challenges to their genetic integrity, having passed through several bottlenecks over a short period of time. A winter-run recovery plan was drafted (NOAA Fisheries 1997), with recommendations for fishing protection measures, a temperature control device at Shasta Dam, and hatchery supplementation. The winter-run population has been increasing in number since 1995, but the ESU is still represented by a single population in an artificial habitat maintained by a dam, and has gone through a minimum of two, separate, genetic bottlenecks. Iviable, self-sustaining habitat.

31.3.1.2 Association Between Natural Populations and Artificial Propagation

Natural populations "with minimal genetic contribution from hatchery fish"

There is one hatchery program in the ESU, located on the Sacramento River, and supported by a captive broodstock component. The program is managed to contribute genetically to the natural population by supplementing the naturally spawning population for the purpose of increasing the number of natural spawners the population. The hatchery program may collect up to 15% of estimated winter-run escapement but no more than 120 natural-origin winter-run per brood year. Hatchery broodstock are spawned following a matrix designed to maximize genetic diversity while minimizing risks to the winter-run effective spawning population. The hatchery production goal is 250,000 sub-yearling smolts for release into the upper Sacramento River basin. The hatchery program had prevented the further loss of alleles in the population and increased its genetic diversity.

Natural[1] populations "that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat" [2]

The ESU population has been increasing in number since 1995, and annual redd and carcass surveys confirm that the winter-run population are spawning in the wild. The winter-run spawning habitat has been reduced by half in 2004, due to the inefficiency of the temperature control device at Shasta Dam; the improvement of screening the Glenn-Colusa Irrigation District diversion pump, which allows winter-run to continue migrating up in the system; and in conjunction with the occurrence of a dry year. It has been estimated that there is adequate spawning and rearing habitat for the 8,000 fish that are expected to spawn this year.

Mixed (Integrated Programs[3])

Winter-run Conservation Program at (Livingston Stone National Fish Hatchery) is an integrated program, and it may collect 90 to 100 percent of its broodstock from the natural population. Production is 100 percent adipose-clipped to distinguish hatchery fish from natural fish.

Hatchery (Isolated[4])

None.

31.3.2. Summary of ESU Viability:

31.3.2.1 Abundance. The risk factors for this ESU, in order of priority, is its spatial structure, diversity, abundance and productivity categories (BRT 2003). Aeria, mark-recapture, and carcass surveys; and counts at Red Bluff Diversion Dam suggest that the abundance of winter-run is increasing. Population growth is estimated at a short-term trend of 0.26; the long-term trend remains a negative one (avg. -0.14). Recent winter-run abundance represents only 3% of the maximum post-1967 5-year geometric mean (BRT 2003).

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[1] See HLP for definition of natural, mixed and hatchery populations

[2] HLP Point 3

[3] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated".

[4] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

31.3.2.2 Productivity. The lowest risk factor for this ESU was in the productivity category (BRT 2003). The long term productivity rate trend for the ESU is negative, but it is positive in the short term with the increasing number of spawning winter-run. The population is still vulnerable to environmental and artificial conditions that could leave the single population at risk.

31.3.2.3 Spatial Structure. The greatest risk factor for winter-run is their spatial structure (BRT 2003). The remnant population has been blocked from the environment from which they've evolved, and are artificially maintained by a network of agencies that have conflicting mandates. Winter-run require cold water temperatures that simulate their upper basin habitat, and currently live in an environment that is subject to cycles of drought. Battle Creek has been targeted for the establishment of a winter-run population, and it remains the lone opportunity for the species to expand or replace its current spatial structure, the upper 25 km reach below Shasta Dam.

31.3.2.4 Diversity. Diversity was identified and the second highest risk for the winter-run ESU. The population is a result of an introgression of several stocks which occurred when Shasta Dam was constructed. A second genetic bottleneck occurred with the construction of Keswick Dam; there may have been several in the 20th century (BRT 2003).

31.3.3. Artificial Propagation Record

31.3.3.1 Experience with Integrated Programs. The winter-run Chinook salmon conservation program at Livingston Stone National Fish Hatchery is the only winter-run artificial propagation program in the ESU. Wild fish are collected from the Keswick Dam fish trap for broodstock purposes. A maximum of 15 percent of estimated winter-run escapement but no more than 120 natural-origin winter-run per brood year may be collected; if necessary, 10 percent may consist of trapped hatchery fish. The hatchery program has been in operation since 1989; operation under the current management strategy began in 1998.

31.3.3.2 Are Integrated Programs Self-Sustaining. The winter-run Chinook salmon conservation program is self-sustaining; i.e., there has been an increase in winter-run adults returning to the upper basin. The average number of fish now required for collection is approximately 100 fish or less; as the natural population increases, it is not as dependent upon artificial propagation..

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